

# Age-Related Differences in Predictors of Adherence to Rehabilitation After Anterior Cruciate Ligament Reconstruction

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**Objective:** To examine whether the relationships between psychological factors and rehabilitation adherence after knee surgery differ as a function of age.

**Design and Setting:** Participants completed inventories of self-motivation, social support, athletic identity, and psychological distress before anterior cruciate ligament (ACL) reconstruction. After surgery, participants recorded their completion of home rehabilitation exercises and cryotherapy, and the sport rehabilitation professionals providing their treatment reported on the patients' attendance at, and adherence during, rehabilitation sessions.

**Subjects:** Sixty-one individuals with acute ACL tears.

**Measurements:** The Self-Motivation Inventory, Social Support Inventory, Athletic Identity Measurement Scale, Brief Symptom Inventory, and Sport Injury Rehabilitation Adherence

Scale were used to measure self-motivation, social support, athletic identity, psychological distress, and adherence, respectively, during rehabilitation sessions.

**Results:** Hierarchic regression analyses indicated that age moderated the relationships between (1) self-motivation and home exercise completion, (2) social support and home exercise completion, (3) athletic identity and home exercise completion, and (4) athletic identity and home cryotherapy completion.

**Conclusions:** The prospective moderating relationships for between psychological factors and indices of adherence to home-based rehabilitation activities indicate the need to consider developmental issues when examining psychological aspects of sport-injury rehabilitation.

**Key Words:** compliance, knee surgery, psychology

Adherence to the prescribed rehabilitation regimen is considered vital for achieving successful recovery from sport injury.<sup>1</sup> Depending on the nature of the injury, adherence to a rehabilitation protocol typically involves active participation in some combination of clinic- and home-based exercises and therapeutic modalities.<sup>2</sup>

Consistent with contemporary psychological models of sport-injury rehabilitation,<sup>3,4</sup> numerous personal and situational factors (eg, self-motivation, social support, mood disturbance) have been linked to sport-injury rehabilitation adherence.<sup>2</sup> Although age was not correlated with indices of sport-injury rehabilitation adherence in one study,<sup>5</sup> the role of developmental factors in the adherence process has not been explored thoroughly. In particular, the potential moderating effects of age on the relationship between psychological factors and sport-injury rehabilitation adherence have not been examined. That is, researchers have not ad-

ressed whether the same psychological factors predict rehabilitation adherence in athletes of different ages. Consequently, the purpose of our study was to investigate whether prospective associations among psychological factors and rehabilitation adherence differ as a function of age through reanalysis of data from a previously published report<sup>5</sup> in which the requisite demographic, psychological, and adherence variables were assessed, but the moderating effects of age were not evaluated.

## METHODS

### Participants

Participants were 61 individuals (21 females, 40 males) with a mean age of  $26.03 \pm 7.99$  years (range, 14–47 years) who completed a battery of psychological inventories before ante-

rior cruciate ligament (ACL) reconstruction and recorded their adherence to home-based rehabilitation activities after surgery. In terms of self-reported race or ethnicity, the sample predominantly consisted of white individuals (89%), with smaller percentages of participants who were Hispanic (5%), black (5%), and Asian or Pacific Islander (2%). The vast majority of participants indicated that they were competitive athletes (57%) or recreational athletes (41%). Most participants (90%) reported that they sustained their ACL injury when involved in a sport activity.

## Measures

**Demographic and Injury-Related Variables.** We obtained demographic and injury-related information from participants through a questionnaire with items pertaining to participants' age, sex, race or ethnicity, date of ACL injury, source of ACL injury, and level of sport involvement.

**Psychological Factors.** We used the Self-Motivation Inventory<sup>6</sup> (SMI), a 40-item questionnaire consisting of 5-point Likert scales, to assess self-motivation, which refers to the tendency of individuals to persevere in the absence of external rewards. Empirical support has been obtained for the reliability, internal consistency, construct validity, and predictive validity of the SMI.<sup>6</sup>

We used the Social Support Inventory<sup>7,8</sup> (SSI), a 39-item questionnaire involving 7-point Likert-type scales with anchors of "not at all satisfied" and "very satisfied," to assess participants' satisfaction with the social support they had received in the previous month. Evidence for the reliability, construct validity, and criterion-related validity of the SSI has been found.<sup>7,8</sup>

We assessed athletic identity (ie, the degree of identification with the athlete role) with the Athletic Identity Measurement Scale<sup>9</sup> (AIMS), a 10-item questionnaire consisting of 7-point Likert-type scales with end points of "strongly disagree" and "strongly agree." The AIMS items include "I consider myself an athlete," "Sport is the most important part of my life," and "I feel bad about myself when I do poorly in sport." Higher scores on the AIMS reflect a stronger investment in being an athlete as a source of self-worth. Adequate test-retest reliability, construct validity, and predictive validity have been documented for the AIMS.

We used the Brief Symptom Inventory<sup>10</sup> (BSI), a 53-item questionnaire including a 5-point Likert format, to assess psychological distress. Evidence for the reliability and validity of the BSI has been documented.<sup>10</sup>

**Adherence.** We measured adherence to clinic-based rehabilitation activities in 2 ways: (1) We calculated the ratio of rehabilitation appointments attended to rehabilitation appointments scheduled for each participant. (2) At each rehabilitation appointment, the professional (eg, physical therapist, athletic trainer) attending to the treatment of each participant on that day completed the Sport Injury Rehabilitation Adherence Scale<sup>11</sup> (SIRAS). On the SIRAS, rehabilitation professionals use 5-point Likert-type scales to rate the intensity with which participants complete rehabilitation exercises, the frequency with which patients follow the practitioner's instructions and advice, and the extent to which patients are receptive to changes in the physical therapy program during that day's session. Researchers have documented support for the test-retest reliability, internal consistency, and criterion-related validity of the SIRAS.<sup>11</sup> To assess adherence to home-based rehabilitation

activities, at each rehabilitation appointment, we asked participants to report on the extent to which they had completed their prescribed home exercises and cryotherapy since their last appointment using a scale from 1 (none) to 10 (all). Means were calculated for each of the adherence measures across all rehabilitation appointments attended.

## Procedures

The methods of this study were approved by the institutional review board at the lead author's place of employment. At a physical therapy appointment about 10 days before ACL reconstructive surgery, participants (and the parents or guardians of minors) completed an informed consent form, the questionnaire assessing demographic and injury-related information, the SMI, the SSI, the AIMS, and the BSI. At each rehabilitation appointment after ACL reconstruction, participants recorded their adherence to home-based rehabilitation activities, and rehabilitation professionals documented the attendance of participants and completed the SIRAS. The orthopaedic surgeons affiliated with the project prescribed for participants an accelerated rehabilitation protocol after ACL reconstruction.<sup>12–16</sup>

## Data Screening and Analysis

To examine the internal consistency of the scales assessing the psychological factors, reliability analyses were performed on the SMI, SSI, AIMS, and BSI. The Cronbach alpha coefficients for the SMI, SSI, AIMS, and BSI were .92, .97, .83, and .95, respectively, indicating acceptable internal consistency for each of the scales. Because of a positively skewed distribution for BSI scores and a negatively skewed distribution for the SIRAS, we applied a log transformation to BSI scores and a reflection and inverse transformation to SIRAS scores to produce more normal distributions. Age was treated as a continuous variable. For each of the adherence measures, we performed a separate hierarchic regression analysis in which SMI, SSI, AIMS, and BSI scores were entered in the first step, age was entered in the second step, and the 2-way interactions between age and SMI, SSI, AIMS, and BSI scores, respectively, were entered in the third step. We analyzed significant interactions using the procedures outlined by Aiken and West.<sup>17</sup> Significant interactions between age and psychological factors in the prediction of rehabilitation adherence were interpreted as evidence of a moderating effect of age.

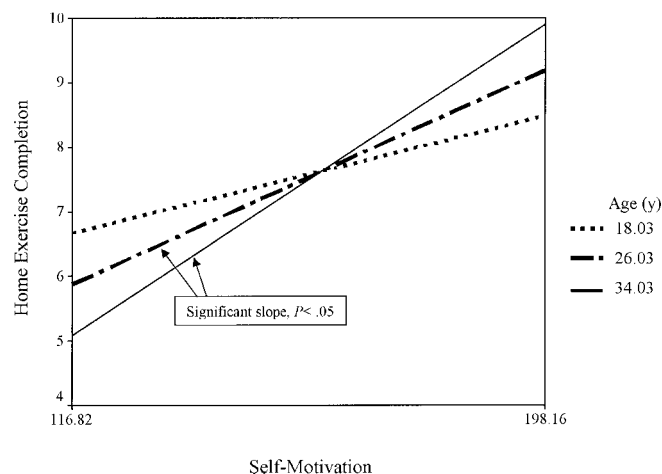
## RESULTS

Although the regression analyses for predicting attendance and SIRAS scores did not achieve statistical significance, including the interaction terms added significantly to the prediction of home exercise completion ( $F_{\text{change } 4,51} = 5.77, P < .01, R^2_{\text{change}} = 0.24, R^2 = .47$ ) and home cryotherapy completion ( $F_{\text{change } 4,51} = 2.91, P < .05, R^2_{\text{change}} = 0.18, R^2 = 0.22$ ) (Table). Self-motivation ( $\beta = 0.37, P < .05$ ) and 3 interactions (age  $\times$  self-motivation,  $\beta = 0.31, P < .05$ ; age  $\times$  social support,  $\beta = 0.25, P < .05$ ; and age  $\times$  athletic identity,  $\beta = -0.48, P < .001$ ) were significant predictors of home exercise completion. To examine the significant interactions, we calculated separate regression equations for 3 values of age: the mean age and 1 SD above and below the mean. As shown in Figures 1 and 2, self-motivation and social support

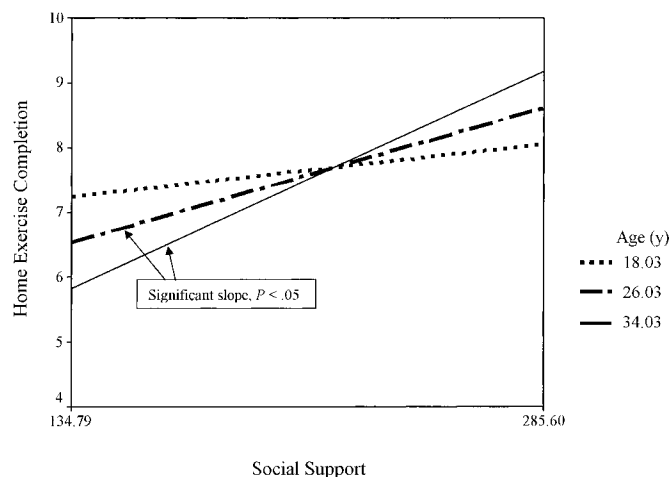
# Means and SDs of Psychological and Adherence Measures

Variable	Mean	SD
Self-motivation	157.49	20.33
Social support	210.20	37.70
Athletic identity	44.16	9.98
Psychological distress	26.61	25.15
Attendance	0.86	0.11
SIRAS*	14.23	0.74
Home exercise completion	7.58	1.95
Home cryotherapy completion	7.66	2.25

\*SIRAS indicates Sport Injury Rehabilitation Adherence Scale.



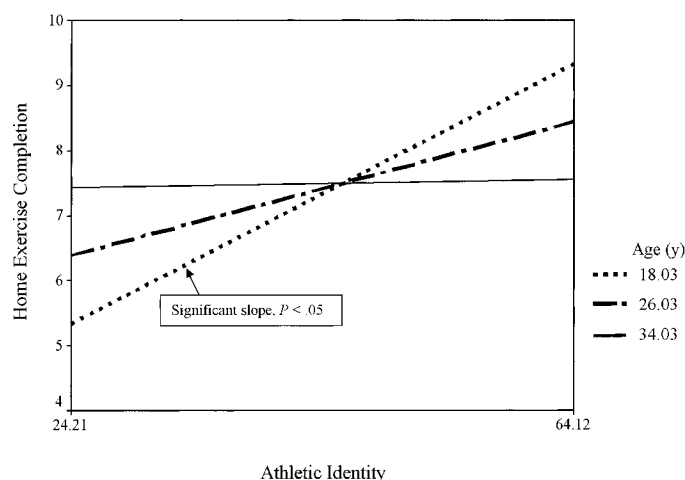
**Figure 1.** Interaction between age and self-motivation for home exercise completion.



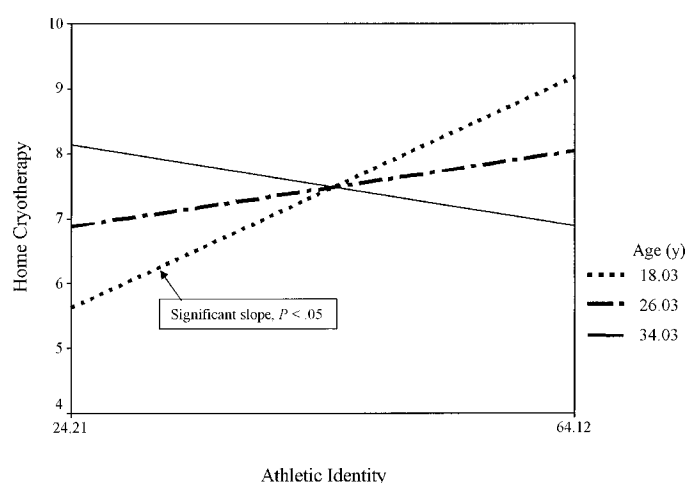
**Figure 2.** Interaction between age and social support for home exercise completion.

were not significantly related to home exercise completion for younger participants, but these constructs were positively associated with home exercise completion for older participants. As depicted in Figure 3, younger participants showed a positive relationship between athletic identity and home exercise completion, but this relationship was not significant for older participants.

Home cryotherapy completion was significantly predicted by the interaction between age and athletic identity ( $\beta = -0.37, P < .05$ ). This interaction was examined by procedures



**Figure 3.** Interaction between age and athletic identity for home exercise completion.



**Figure 4.** Interaction between age and athletic identity for home cryotherapy completion.

identical to those used for the previous significant interactions. As illustrated in Figure 4, younger participants showed a positive relationship between athletic identity and home cryotherapy completion, and older participants showed no significant relationship between these variables.

## DISCUSSION

Age moderated the prospective relationships between selected psychological factors and adherence to home rehabilitation activities after ACL reconstruction. In the original analysis of the data used in the current investigation,<sup>5</sup> the sole significant predictor of any of the adherence variables was self-motivation, which was positively associated with home exercise completion. Including age as a moderator in the present analyses not only clarified the relationship between self-motivation and home exercise completion but also implicated other variables in the adherence process. Both self-motivation and social support were positively associated with home exercise completion only for older participants, whereas athletic identity was positively associated with both home exercise completion and home cryotherapy completion only for younger participants (who consisted primarily of adolescents). In-

clusion of age in the analyses clearly improved the explanatory power of the psychological variables as predictors of adherence to home-based rehabilitation activities and revealed relationships that were not otherwise observed in regression models that examined only the main effects of the psychological variables.

Although self-motivation is relevant to the adherence of adolescents and young adults to sport-injury rehabilitation programs, as evidenced by the findings of other investigators,<sup>18–20</sup> the adherence of the younger participants to home rehabilitation activities in the current study was related more strongly to athletic identity. Identity development is a central developmental task of adolescence<sup>21</sup>; it is therefore not surprising that self-identification with the athlete role may be especially salient in affecting an adolescent's commitment to rehabilitation behavior in the home, removed from the influences of the rehabilitation professionals in the clinical setting. Returning to sport may be more of a priority for patients who are high in athletic identity, and this may be reflected in their approach to the home-based part of the rehabilitation regimen.

It is unclear why age did not serve as a moderator in the relationships between psychological factors and adherence to clinic-based rehabilitation. One possible explanation is that within the clinical rehabilitation environment, characteristics of the rehabilitation professional and the quality of the relationship between the rehabilitation professional and the patient may be more relevant to the adherence process than the age of the patient. Further research is needed to explore this possibility.

Several limitations should be taken into account when interpreting the findings of the current study. First, although restricting the sample of participants to individuals undergoing rehabilitation after ACL reconstruction provided a more controlled exploration of the moderating effects of age by reducing cross-participant variability in injury severity and the demands of the rehabilitation regimen, such homogeneity decreased the generalizability of the results. Additional inquiry with other levels of injury severity and rehabilitation programs is needed to assess the generalizability of the current findings. Second, despite the prospective, longitudinal research design used in this investigation, causal relationships between psychological factors and rehabilitation adherence cannot be inferred. Experimental studies in which factors such as self-motivation, social support, and athletic identity are manipulated and the effects of these variables on subsequent adherence are examined are required to address the issue of causality and the role of age in the adherence process. Third, given the self-report method used to assess adherence to home rehabilitation activities, further research using more objective measures of home rehabilitation adherence is needed to corroborate the current findings. Although there is no reason to assume that participants' self-reports of home rehabilitation adherence are differentially distorted as a function of age, use of electronic monitors<sup>22</sup> and other measures that are less susceptible to recall bias may enhance the accuracy of home rehabilitation adherence data.

From a practical standpoint, our results suggest that the age of athletes with injuries may be an important factor to consider when planning sport-injury rehabilitation programs. Should the current findings be replicated in future research, the development, implementation, and evaluation of interventions to enhance sport-injury rehabilitation adherence<sup>23,24</sup> with age-specific foci would be warranted. Enhancing adherence to

sport-injury rehabilitation programs has the potential to improve the rehabilitation outcomes of athletes of all ages.<sup>25–29</sup>

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## REFERENCES

1. Taylor J, Taylor S. *Psychological Approaches to Sports Injury Rehabilitation*. Gaithersburg, MD: Aspen Press; 1997.
2. Brewer BW. Adherence to sport injury rehabilitation regimens. In: Bull SJ, ed. *Adherence Issues in Sport and Exercise*. Chichester, UK: John Wiley & Sons; 1999:145–168.
3. Brewer BW. Review and critique of models of psychological adjustment to athletic injury. *J Appl Sport Psychol*. 1994;6:87–100.
4. Wiese-Bjornstal DM, Smith AM, Shaffer SM, Morrey MA. An integrated model of response to sport injury: psychological and sociological dynamics. *J Appl Sport Psychol*. 1998;10:46–69.
5. Brewer BW, Van Raalte JL, Cornelius AE, et al. Psychological factors, rehabilitation adherence, and rehabilitation outcome following anterior cruciate ligament reconstruction. *Rehabil Psychol*. 2000;45:20–37.
6. Dishman RK, Ickes W. Self-motivation and adherence to therapeutic exercise. *J Behav Med*. 1981;4:421–438.
7. Brown SD, Alpert D, Lent RW, Hunt G, Brady T. Perceived social support among college students: factor structure of the Social Support Inventory. *J Counsel Psychol*. 1988;35:472–478.
8. Brown SD, Brady T, Lent RW, Wolfert J, Hall S. Perceived social support among college students: three studies of the psychometric characteristics and counseling uses of the Social Support Inventory. *J Counsel Psychol*. 1987;34:337–354.
9. Brewer BW, Van Raalte JL, Linder DE. Athletic identity: Hercules' muscles or Achilles heel? *Int J Sport Psychol*. 1993;24:237–254.
10. Derogatis L. *The Brief Symptom Inventory (BSI) Administration, Scoring & Procedures Manual—II*. 2nd ed. Baltimore, MD: Clinical Psychometric Research; 1992.
11. Brewer BW, Van Raalte JL, Petitpas AJ, et al. Preliminary psychometric evaluation of a measure of adherence to clinic-based sport injury rehabilitation. *Phys Ther Sport*. 2000;1:68–74.
12. DeCarlo MS, Sell DE, Shelbourne KD, Klootwyk TE. Current concepts on accelerated ACL rehabilitation. *J Sport Rehabil*. 1994;3:304–318.
13. DeCarlo MS, Shelbourne KD, McCarroll JR, Rettig AC. Traditional versus accelerated rehabilitation following ACL reconstruction: a one-year follow-up. *J Orthop Sports Phys Ther*. 1992;15:309–316.
14. Shelbourne KD, Klootwyk TE, DeCarlo MS. Update on accelerated rehabilitation after anterior cruciate ligament reconstruction. *J Orthop Sports Phys Ther*. 1992;15:303–308.
15. Shelbourne KD, Nitz P. Accelerated rehabilitation after anterior cruciate ligament reconstruction. *Am J Sports Med*. 1990;18:292–299.
16. Shelbourne KD, Wilckens JH. Current concepts in anterior cruciate ligament rehabilitation. *Orthop Rev*. 1990;19:957–964.
17. Aiken LS, West SG. *Multiple Regression: Testing and Interpreting Interactions*. Newbury Park, CA: Sage; 1991.
18. Duda JL, Smart AE, Tappe MK. Predictors of adherence in rehabilitation of athletic injuries: an application of personal investment theory. *J Sport Exerc Psychol*. 1989;11:367–381.
19. Fields J, Murphey M, Horodyski M, Stopka C. Factors associated with



- adherence to sport injury rehabilitation in college-age recreational athletes. *J Sport Rehabil.* 1995;4:172–180.
20. Fisher AC, Domm MA, Wuest DA. Adherence to sports-injury rehabilitation programs. *Physician Sportsmed.* 1988;16(7):47–52.
  21. Erikson EH. Identity and the life cycle. *Psychol Issues.* 1959;1:1–171.
  22. Levitt R, Deisinger JA, Remondet Wall JR, Ford L, Cassisi JE. EMG feedback-assisted postoperative rehabilitation of minor arthroscopic knee surgeries. *J Sports Med Phys Fitness.* 1995;35:218–223.
  23. Fisher AC, Scriber KC, Matheny ML, Alderman MH, Bitting LA. Enhancing athletic injury rehabilitation adherence. *J Athl Train.* 1993;28:312–318.
  24. Worrell TW. The use of behavioral and cognitive techniques to facilitate achievement of rehabilitation goals. *J Sport Rehabil.* 1992;1:69–75.
  25. Derscheid GL, Feiring DC. A statistical analysis to characterize treatment adherence of the 18 most common diagnoses seen at a sports medicine clinic. *J Orthop Sports Phys Ther.* 1987;9:40–46.
  26. Hawkins RB. Arthroscopic stapling repair for shoulder instability: a retrospective study of 50 cases. *Arthroscopy.* 1989;2:122–128.
  27. Meani E, Migliorini S, Tinti G. La patologia de sovraccarico sportivo dei nuclei di accrescimento apofisari [The pathology of apophyseal growth centers caused by overstrain during sports]. *Ital J Sports Traumatol.* 1986;8:29–38.
  28. Noyes FR, Matthews DS, Mooar PA, Grood ES. The symptomatic anterior cruciate-deficient knee, part II: the results of rehabilitation, activity modification, and counseling on functional disability. *J Bone Joint Surg Am.* 1983;65:163–174.
  29. Satterfield MJ, Dowden D, Yasamura K. Patient compliance for successful stress fracture rehabilitation. *J Orthop Sports Phys Ther.* 1990;11:321–324.